Boyd County, Kentucky
Sulfur Dioxide (SO_2)
Attainment Modeling Documentation

Prepared by:

U.S. EPA Region 4,
U.S. EPA Region 3,
Kentucky Division of Air Quality
West Virginia Department of Environmental Protection

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BOYD COUNTY SO2 ATTAINMENT MODELING

I. <u>Model Selection</u>

EPA Regions 3 and 4, the Kentucky Division of Air Quality (KY DAQ) and the West Virginia Department of Environmental Protection (WV DEP) jointly developed air dispersion modeling for the Boyd County, Kentucky sulfur dioxide (SO2) nonattainment area. The modeling procedures applied in the demonstration of attainment for the Boyd County, Kentucky nonattainment area were based on the use of the American Meteorological Society (**AMS**)/ United Stated Environmental Protection Agency (**EPA**) **R**egulatory **M**odel **I**mprovement **C**ommittee (AERMIC) **Mod**el (AERMOD). The AERMOD modeling system represents an improvement in regulatory steady-state plume modeling. This modeling system includes: (1) innovative air turbulence structure, scaling and concepts; (2) treatment of both surface and elevated sources; 3) treatment of both simple and complex terrain, and 4) the PRIME downwash algorithm. The modeling system consists of 3 components: AERMOD (the air dispersion model), the **AER**MOD **met**eorological preprocessor (AERMET), and the **AER**MOD **map**ping program for processing terrain and generating receptors (AERMAP). The latest versions of this modeling platform were used: AERMOD and AERMET (version 02222), and AERMAP (version. 03107). The AERMOD modeling system used in this analysis can be found on the Support Center for Regulatory Models (SCRAM) Internet site, i.e., http://www.epa.gov/ttn/scram/.

The Industrial Source Complex (ISC3) model is the current Agency preferred model for air quality impact analysis of stationary sources for most criteria pollutants. The use of non-guideline models, such as AERMOD, is allowed under section 3.2 of the EPA guidance, "Appendix W of 40 CFR Part 51: Guideline on Air Quality Models" (Modeling Guideline) and 40 CFR 51.112. This section of the Modeling Guideline permits the use of an alternative model provided EPA approves the justification for its use. Kentucky DAQ requested that EPA approve the use of the AERMOD non-guideline model in a letter dated October 20, 2003. EPA Region 4 approved AERMOD for this application in a November 12, 2003, letter from the EPA Region 4 Regional Administrator. The KY DAQ letter requesting the use of AERMOD provided the necessary rationale for Region 4's acceptance. AERMOD was proposed as the next Environmental Protection Agency (EPA) regulatory model in the April 20, 2000 <u>Federal Register</u> (65 FR 21506). AERMOD is a state-of-the-practice Gaussian plume dispersion model whose formulation is based on planetary boundary layer principles. AERMOD employs the well-known dividing-streamline concept (i.e., as used in the CTDMPLUS model) in a simplified simulation of the effects of plume-terrain interactions. AERMOD offers a more modern characterization of plume dispersion than does the ISC3 model it is proposed to replace. AERMOD utilizes directly observed variables of the boundary layer to parameterize dispersion. AERMOD is proposed to become a preferred model in the EPA Modeling Guideline. The **P**lume **Ri**se **M**odel **E**nhancements (PRIME) algorithm is included in AERMOD. A discussion of the model and latest enhancements are presented in the paper, "AERMOD Latest Features and Evaluation Results," on the SCRAM Internet site (http://www.epa.gov/ttn/scram/) under AERMOD_MEP on the 7th Modeling Conference webpage under the section entitled AERMOD Beta Test.

II. AERMET PREPROCESSOR

Meteorological Data

Meteorological data (i.e., wind speed and wind direction) from 1991 collected at the Cooper School tower in Kentucky near the Marathon Oil facility were used in this assessment. The tower is located approximately 1.3 miles south of Catlettsburg, Kentucky. The location of the Cooper School tower is shown in Figure 1. The anemometer height of the Cooper School tower is 10 meters (m) above the ground. The base elevation for the Cooper School tower is 201.2 m (660 feet) above mean sea level (MSL). These data were chosen for this attainment modeling application because many of the stacks have heights of 12- 20 m and the tower is located near many of the important sources. Therefore, wind speed and direction data from the tower should be representative of stack-top conditions. Figure 1.1 presents a wind rose of the 1991 data measured at the Cooper School tower. The Cooper School data were analyzed to determine missing periods of data. For missing wind data periods of three hours or less, interpolation of the last valid hour before and after the periods of missing data was used to fill the data gaps. For longer periods of missing data, the AERMET option to substitute data from the National Weather Service (NWS) Station was used. Data from the Huntington/Tri-State Airport West Virginia NWS station (Weather-Bureau-Army-Navy (WBAN) identification number 03860) was used. The location of the Huntington/Tri-State Airport NWS station is shown on Figure 1. It's base elevation is 251.8 m (826 feet) above MSL with an anemometer height of 6.1 m (20 feet).

A morning sounding (in National Weather Service format) from a representative upper air station, latitude, longitude, time zone, and wind speed threshold is also required in AERMET. Optionally, measurements of solar radiation, net radiation, profiles of wind, temperature, and vertical and lateral turbulence may be input to AERMET. The wind data from the Cooper School was combined with the temperature, cloud cover and upper air measurements from the Huntington/Tri-State Airport West Virginia NWS station.

Surface Characteristics

The AERMET model is used to develop hourly sequential meteorological data to estimate concentrations for averaging times from one hour to one year. AERMET processes meteorological data for input to AERMOD. Surface characteristics (i.e., surface roughness, Bowen ratio, and albedo by sector and season or month) and hourly observations of wind speed, wind direction, cloud cover, and temperature are required inputs to the AERMET meteorological preprocessor. The surface characteristics should represent the surface characteristics in the vicinity of the meteorological tower. The surface characteristics for this modeling demonstration were developed from an analysis of the land use characteristics within a 3 km radius of the Cooper School met tower. A 1:250,000 USGS Land Use Land Cover (LULC) map was used to determine the land use categories for the analysis. Figure 2 shows the land use categories within the 3 kilometers (km) radius of the Cooper School met tower. Since data from the Huntington/Tri-State NWS station was also used in the analysis, the land-use characteristics surrounding its location were also examined. As can be seen in Figure 2, the land use characteristics surrounding the NWS station are similar to the Cooper School site, with slightly more agricultural land and less urban land than surrounding the Cooper School tower, but overall they are similar. Since the Cooper School tower was the primary source of wind speed and direction measurements, it was chosen as the location for calculating the albedo, Bowen ratio and surface roughness in AERMET.

Tables 4-1 through 4-3 in the AERMET User's Guide[1] provide values of albedo, Bowen ratio, and surface roughness for varying land-use types and seasons. The 3 km radius circle surrounding the Cooper School tower was broken into four sectors as shown in Figure 2. Areal-averaged values of albedo, Bowen ratio and surface roughness were determined for each of these four sectors by using the ratio of the area of each land-use type to the total area of the sector. These area ratios were multiplied by the appropriate values found in Tables 4-1 through 4-3 of the AERMET User's Guide to estimate the site-specific values for albedo, Bowen ratio, and surface roughness which are required inputs for AERMET. Table 1 provides the calculated values of albedo, Bowen ratio and surface roughness. The complete details of this analysis are provided in a Microsoft Excel spreadsheet on the attached CD-ROM

[1] Environmental Protection Agency, 1998. AERMET User's Manual. U.S. Environmental Protection Agency, Research Triangle Park, NC. Located on the EPA SCRAM website at http://www.epa.gov/ttn/scram/

Table 1. Surface Characteristics				
Northeast Sector				
	Spring	**Summer**	**Fall**	**Winter**
Albedo	0.135	0.153	0.164	0.397
Bowen Ratio	0.834	1.390	1.567	1.500
Surface Roughness (m)	0.896	0.967	0.862	0.804
Southest Sector				
	Spring	**Summer**	**Fall**	**Winter**
Albedo	0.132	0.144	0.150	0.451
Bowen Ratio	0.819	1.020	1.436	1.575
Surface Roughness (m)	0.909	1.080	0.806	0.643
Southwest Sector				
	Spring	**Summer**	**Fall**	**Winter**
Albedo	0.129	0.142	0.141	0.482
Bowen Ratio	0.710	0.627	1.148	1.570
Surface Roughness (m)	0.851	1.057	0.737	0.551
Northwest Sector				
	Spring	**Summer**	**Fall**	**Winter**
Albedo	0.125	0.132	0.134	0.430
Bowen Ratio	0.708	0.556	1.038	1.500
Surface Roughness (m)	1.033	1.164	0.957	0.837

AERMET Output Files

The AERMET meteorological preprocessor produces two files for input to the AERMOD dispersion model. The surface file contains observed and calculated surface variables (e.g., albedo, Bowen ratio, surface roughness, Monin-Obukhov length, mixing height, sensible heat flux, etc). The profile file contains the observations made at each tower level, or the single-level observations taken from other representative data (e.g., National Weather Service surface observations). For this analysis, observations at multiple levels were not available at the Cooper School meteorological tower. Therefore, the profile file contains a single level of merged observations from the Cooper School tower (wind speed and direction) and the NWS station (temperature). The AERMOD model uses this single level of observations to a generate vertical profile of meteorological parameters. The input files for the AERMET preprocessor were developed according to the AERMET User's Guide.[1] The input and out put files for AERMET are included on the attached CD-ROM.

III. AERMAP PREPROCESSOR

Topography

Boyd County is located in the northeastern part of Kentucky. The area is bounded by the Big Sandy River and West Virginia on the east and the Ohio River and Ohio on the north. Figure 3 illustrates a topographic map of the SO_2 nonattainment area and the SO_2 emission sources that were modeled in the surrounding area. The terrain is characterized by a relatively flat plateau with steep terrain surrounding the Big Sandy River valley. Figure 3.1 shows a detailed map of the topography over the final modeling receptor grid area. Most of the stack heights of the sources within the modeling area are less than the height of the surrounding plateau; therefore, complex-modeling techniques are required for the attainment modeling demonstration.

Rural versus Urban Land Use Analysis

An analysis was performed to determine if the area surrounding sources of interest should be classified as urban or rural for the air dispersion modeling. The Auer Classification Typing Scheme 1[2] was used with 7.5 minute (1:250,000) land use data, from a U.S. Geological Survey (USGS) digital land use land cover (LULC) file, within a 3 km radius for this analysis. This is the same data set that was used to determine the surface characteristics for AERMET in the discussion above (See Figure 2). The analysis indicated that only 32 percent (%) of the area could be classified as residential, commercial or industrial. The remainder is considered to be cropland and pasture, forested or transitional areas. Table 2 shows each USGS land-use classification and corresponding description. Because the majority of the area within the 3 km radius is considered to be rural, rural dispersion coefficients will be utilized in the modeling.

Table 2.
USGS Land-use Classifications and Descriptions

Code	Classification	Description
1	Urban or Built-Up Land	Residential, Commercial, Industrial, Transportation, Communications, and Mixed Urban or Built-Up Land
2	Agricultural Land	Cropland and Pasture, Orchards, Groves, Vineyards, Nurseries, Confined Feeding Operations
3	Rangeland	Herbaceous, Shrub and Brush Rangeland
4	Forest Land	Deciduous, Evergreen and Mixed Forrest Land
5	Water	Streams, Lakes, Reservoirs, and Bays/Estuaries
6	Wetland	Forested and Non-forested Wetlands
7	Barren Land	Dry Salt Flats, Beaches, Sandy Areas, Bare Exposed Rock, Strip Mines, Quarries, Gravel Pits, and Transitional Areas
8	Tundra	Shrub and Brush, Herbaceous, Bare and Wet Tundra
9	Perennial Snow and Ice	Perennial Snowfields and Glaciers

[2] Auer, JR., A. H., *Correlation of Land Use and Cover with Meteorological Anomalies*, Journal of Applied Meteorology, Vol. 17, pp. 636-643, 1978.

Receptor Grids

The AERMAP terrain preprocessor uses receptor coordinates, elevations, and height above ground, to produce hill-height scales for input in AERMOD. Discrete receptors and/or multiple receptor grids (i.e., Cartesian and/or polar) may be employed in AERMOD. AERMAP requires input of Digital Elevation Model (DEM) terrain data produced by the USGS, or other equivalent data. AERMAP was used to estimate source and receptor elevations. The preprocessor inputs were developed according to the AERMAP user's guide[3] and are included the AERMAP directory of the attached CD-ROM. For this analysis, thirty (30) 7.5-minute USGS DEM files were used to cover the entire modeling domain.

Three receptor grids were used in the attainment demonstration modeling: (1) a coarse Cartesian receptor grid with 1000-m spacing and (2) two grids of 250-m spacing. Figure 4 illustrates the location and size of the different grids. The coarse receptor grid (outlined in red in Figure 4) was used to identify areas of high concentrations that could merit closer analysis. It encompasses the Boyd County SO2 nonattainment area and has dimensions of approximately 23 km by 27 km for a total area of 621 square km. The results of the initial coarse grid model runs (Figures 7, 8 and 9) indicate that the largest modeled concentration impacts were confined to an area centered on the Big Sandy River Valley (receptor area outlined in yellow) and an area in the north-northeastern part of Boyd County (receptor area outlined in blue). The fine (i.e., 10 km x 13 km) resolution grid of 250-m spacing outlined in yellow was used to identify the highest controlling concentration.

IV. <u>AERMOD Modeling</u>

Input Development

The AERMET and AERMAP preprocessor outputs were used as input for running the AERMOD air dispersion model. The inputs were developed according to the AERMOD user's guide.[4] The model was run in the default mode of operation. These options include stack-tip downwash, and a routine for processing averages when clam winds or missing meteorological data occur. The sources were modeled with maximum allowable emission rates as discussed above. The input and output files for the AERMOD model runs are included on the attached CD.

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[3] Environmental Protection Agency, 1998. User's Guide for the AERMOD Meteorological Preprocessor (AERMET), Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711. Located on the EPA SCRAM website: http://www.epa.gov/ttn/scram/.

[4] Environmental Protection Agency, 1998. User's Guide for the AMS/EPA Regulatory Model - AERMOD, Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711. Located on SCRAM website: at http://www.epa.gov/ttn/scram/.

Building Downwash and Good Engineering Practice (GEP) Stack Height Analysis

Stack-tip downwash and buoyancy induced dispersion effects are modeled with AERMOD. Building wake effects are simulated for stacks less than good engineering practice. The EPA Building Profile Input Program (BPIP)-Prime model was used to determine the GEP stack height and to develop the building input data for each applicable source (i.e., any emission source with stack height less than GEP). The modeling of building downwash was performed for sources located in, or near the SO2 nonattainment area. Figure 5 shows the sources that were modeled for building downwash. Detailed data (i.e., BPIP-Prime input and output files and plot files for the sources subject to downwash modeling are included in the attached CD-ROM.

Modeling Emission Inventory

EPA's Modeling Guideline states that, "all sources expected to cause a significant concentration gradient in the vicinity of the source or sources under consideration for emission limits(s) should be explicitly modeled." Required input includes source type, location, emission rate, stack height, stack inside diameter, stack gas exit velocity, stack gas temperature, area and volume source dimensions, and source elevation. Building dimensions and variable emission rates are optional and are subject to whether or not modeling for building downwash is performed. Maximum allowable and/or permit SO2 emission rates were used as inputs to the model for each source specifically modeled. The emissions inventory developed by ENSR consultants in a preliminary modeling study for this area[5] was used in this modeling demonstration (with some changes discussed below). In the ENSR-developed modeling, major sources (i.e., ≥100 tons per year) emission sources within 50 km of the Boyd County, Kentucky SO2 nonattainment area were reviewed for inclusion in the modeling inventory. One additional minor source that is located within Boyd County was also modeled. The ENSR report provides more details on the complete list of sources initially considered for dispersion modeling, their locations, allowable emissions and the final list of sources that were modeled. It also discusses the status of some of the sources that were initially considered for modeling but were omitted due to shut downs or other operational changes.

This modeling analysis includes changes to the ENSR-developed modeling emissions inventory. The most significant changes to the ENSR-developed inventory were to source emissions and stack parameters for the Sunoco (formerly Aristech/Neal in ENSR modeling) and Calgon Big Sandy facilities, since these two facilities were found to be the primary contributors to the high modeled concentrations in the ENSR report. The revisions for Calgon and Sunoco were based on data provided by the KY DAQ and WV DEP, respectively, and are discussed in detail in the following sections. The changes to the maximum allowable emission limits and other operating conditions are included in revisions to permits that are discussed elsewhere in the State Implementation Plan (SIP).

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[5]Ashland Petroleum Company, Ashland, Kentucky, *Dispersion Modeling Phase I Results: Demonstration of SO2 Attainment for Boyd County, Kentucky*, Document Number 8505-576-400, prepared by ENSR Corporation, April 2001

In addition to the changes for the Sunoco and Calgon facilities discussed in the following sections, some minor changes were made to correct errors found in the ENSR-developed inventory. These errors were primarily related to the locations of some of the emissions sources and changes since the inventory was developed.

- Sources at the Marathon-Ashland Marine Repair facility were incorrectly located in Ohio when they should have been located across the river in Boyd County, Kentucky.
- One of the sources at the Marathon-Ashland Marine Repair facility has been shut down and a new source has been added at the facility since the ENSR report was done.
- The ENSR report contains a typographical error for the location of one of the sources at the AK Steel Coke Plant.
- A review of the source locations at the Calgon facility indicated that some of the sources were incorrectly located by up to 200 meters.
- A natural gas-fired boiler has been added to the list of sources that are permitted at the Calgon facility.

Representatives from the KY DAQ visited these facilities and obtained accurate source locations using hand-held GPS units to correct the location errors from the ENSR Report.

Table 3 provides a list of individual emission sources modeled in this demonstration (including the revisions/updates discussed above and in the following sections). This table includes source locations in Universal Transverse Mercator coordinates (UTM), stack identifications, stack parameters, and stack emissions. Table 4 provides a cross-reference between the source identification names used in modeling files and its associated facility's names. Figure 3 illustrates the location of the modeled facilities relative to the Boyd County nonattainment area.

Revisions to Calgon Emission Sources[6]

The emission inventory for the Calgon Big Sandy facility involves emission rate and/or stack parameters (i.e., temperature, stack height) changes that will be incorporated into the facility's Title V permits. The B-Line #3 Carbon Activator (Source ID: CALEP14) will be equipped with a scrubber with a control efficiency of 90 percent (%). The SO2 emissions from the C-Line #5 and #6 Carbon Activators (source ID: CALEP21) will be routed to a single scrubber with a 90 % control efficiency. The Calgon emission sources subject to reduced emission rates, include the following units:

- D-Line Bakers (CALEP31)
- D-Line #7 and #8 Activators (CALEP34)
- E-Line Bakers (CALEP39)
- E-Line #9 and #10 Activators (CALEP42)

Emissions from the Acid Wash Process (CALEP26) were included in the modeling for Calgon sources. These emissions were omitted from the original modeling analysis prepared by ENSR. Other changes to the Calgon modeling inventory that are different from the ENSR modeling includes

[6] Based on July 30,2003, letter to Stuart Ecton (KYDAQ) from L.S. Heflin of Calgon Carbon Corporation

a revisions/corrections of stack parameters, including stack heights, exhaust temperatures, and diameters, for various sources. These updates include:

- Refinement of stack exhaust temperatures for the D-Line Bakers (CALEP31) and E-Line Bakers (CALEP39) from 330 degrees Kelvin (K) to 336 K
- Refinement of the stack heights of the scrubbers controlling emissions from the B-Line Activator (CALEP14) and C-Line Activators (CALEP21) from 35 m to 36.6 m
- Refinement of the stack diameters of the scrubbers controlling emissions from the B-Line Activator (CALEP14) and C-Line Activator (CALEP21) from 0.97 m (each) to 0.9 m and 1.37 m, respectively

A final modification to the modeled sources is the renaming of the modeling ID number for the B-Line Baker Heaters. This model ID was revised from CALEP13 to CALEP12 to reflect the source identification number in the facility's current Title V permit. Each of the above changes is included in Table 3 that summarizes the updated emission inventory for the Calgon sources that was used in this modeling analysis.

Revisions to Sunoco Emission Sources

The Sunoco, Neal Facility was formerly known as the "Aristech" facility in the previous ENSR modeling analysis. The following corrections were made to the modeling input parameters used in the ENSR analysis for the Sunoco facility emission sources:

> In May of 1998, a baghouse was constructed for particulate matter control of the main Coal Boiler (ENSR Source Number 0124, now ARIS001). A new stack was also constructed at this time and relocated to the northwest corner of the boiler building. The approximate UTM (zone 17) coordinates of the new stack are; Easting 360,700 meters and Northing 4,246,315 meters. The emission parameters for the new stack were also updated from the ENSR analysis and are listed in Table 3.
>
> The back up boiler (ENSR Source Number 0125, now removed from the analysis) is a 77 mm Btu/hr natural gas fired boiler and the corresponding SO2 emissions are therefore insignificant. For purposes of WV code 45CSR10A (monitoring and recordkeeping plans) the facility has certified that the SO2 emissions from the natural gas fired boiler, the two propane fired boilers, and all other manufacturing sources at the facility are below the 500 lb/yr (0.0072 g/s) potential to emit threshold exemption detailed in section 3.1.c of 45CSR10A. This source was therefore incorrectly included in the ENSR modeling inventory for Sunoco.

Therefore, the only significant source of Sulfur Dioxide emissions at the Neal Facility is the 155 mmBtu/hr Stoker type coal fired boiler. This boiler was previously unpermitted and therefore had an allowable emission rate of 496 lb/hr, or 62.5 g/s (ENSR analysis).

Sunoco has since applied for, and was issued a Class I Administrative Update to establish a Federally enforceable limit on Sulfur Dioxide emissions for the coal boiler. Permit R13-1830C was issued on September 24, 2003, and established a maximum SO2 emission rate of 282 pounds per hour, or 35.5 grams per second.

TABLE 3. BOYD COUNTY SO_2 AERMOD MODELING EMISSION INVENTORY

SOURCE ID	EMISSION RATE (grams/sec)	EMISSION LOCATION X (meters)	Y (meters)	BASE ELEVATION (meters)	STACK HEIGHT (meters)	STACK TEMP (deg. K)	STACK EXIT VEL. (m/sec)	STACK DIAMETER (meters)
CATS001	6.80e-01	360300	4248610	169	38.1	664	25.5	1.83
CATS003	2.52e-01	360350	4248615	169	27.5	664	8.8	1.83
CATS004	7.75e+00	360375	4248545	169	53.4	686	5.8	2.97
CATS005	7.75e+00	360375	4248555	169	53.4	600	5.1	2.97
CATS010	6.17e-01	360365	4248500	169	40.3	486	5	2.9
CATS012	2.22e-01	360454	4248900	163	33.6	561	3.5	1.31
CATS013	2.52e-01	360280	4248285	169	45.9	441	3	2.14
CATS014	1.12e+00	360280	4248275	169	23.2	464	16.2	1.98
CATS015	2.65e-01	360322	4248260	169	12.2	422	10.5	1.16
CATS016	2.65e-01	360322	4248261	169	12.2	411	12.1	1.16
CATS017	2.90e+02	360290	4248680	170	53.4	534	14.9	3.66
CATS018	9.03e+00	360302	4247287	169	53.4	533	9	1.75
CATS019	1.70e-01	360270	4247327	169	21.9	694	11.3	1.22
CATS020	1.51e-01	360297	4247245	169	30.5	472	7.5	1.22
CATS023	3.65e-01	360460	4247790	169	24.6	547	8.9	1.83
CATS028	2.39e-01	360465	4247820	169	13.7	636	16.8	1.07
CATS029	2.14e-01	360472	4247820	169	20.5	589	10.4	1.3
CATS035	2.39e-01	360435	4247930	169	42.7	522	4.9	1.83
CATS037	2.65e-01	360460	4247730	169	12.2	422	10.6	1.17
CATS038	2.65e-01	360455	4247730	169	12.2	422	10.6	1.17
CATS040	7.06e-01	360530	4248910	163	50.3	508	6.1	2.06
CATS042	6.30e+00	360519	4248830	163	76.3	450	3.1	1.53
CATS043	2.27e-01	360615	4248910	163	61.3	544	5.9	1.83
CATS044	2.27e-01	360640	4248910	163	61.3	553	6	1.83
CATS045	7.51e+00	360630	4248910	163	63.3	597	5.7	2.21
CATS046	7.59e+00	360665	4248915	163	56.4	505	8.3	1.83
CATS047	3.91e-01	360665	4248912	163	56.4	500	8.3	1.83
CATS049	2.39e-01	360460	4247821	169	13.7	566	17.8	1.07
CATS050	3.15e-01	360440	4247738	169	45.8	539	7.8	2.14
CATS051	1.26e+00	360560	4248810	163	53.4	450	12.4	2.36
CATS053	1.51e-01	360260	4247285	169	19.5	736	6.6	1.53
CATS054	3.59e-01	360470	4247987	169	53.4	441	5.5	2.06
CATS055	7.61e+00	360495	4247970	169	53.4	430	2.2	2.52
CATS056	4.28e-01	360540	4248050	169	45.8	439	5.8	2.14
CATS058	1.57e+01	360390	4248030	169	76.3	633	10.1	2.67
CATS059	1.42e+00	360390	4248030	169	76.3	633	10.1	0.88
CATS060	5.47e-01	360330	4248648	170	76.3	455	6	2.81
CATS064	5.29e-01	360685	4248787	163	76.3	469	8.2	1.83
CATS065	3.25e-01	360390	4248320	169	76.3	436	5	2.11
CATS066	1.23e+02	360154	4248394	192	70.2	455	18.5	5.49
CATS068	2.07e-01	360350	4248900	166	53.4	522	6.6	1.47
CATS069	2.07e-01	360350	4248900	166	53.4	522	6.6	1.47
CATS070	3.76e-01	360350	4248900	166	53.4	522	5.8	2.11
CATS074	4.54e-01	360090	4248409	192	74.7	1089	12.4	2.29

TABLE 3. BOYD COUNTY SO_2 AERMOD MODELING EMISSION INVENTORY

SOURCE ID	EMISSION RATE (grams/sec)	EMISSION LOCATION X (meters)	EMISSION LOCATION Y (meters)	BASE ELEVATION (meters)	STACK HEIGHT (meters)	STACK TEMP (deg. K)	STACK EXIT VEL. (m/sec)	STACK DIAMETER (meters)
CATS105	1.81e-01	360450	4247800	169	53.4	569	4.8	1.59
CATS109	5.49e-01	360660	4248740	163	54.9	536	9.1	2.36
CATS110	5.87e-01	360660	4248740	163	54.9	533	8.2	2.36
CATS111	4.25e-01	360660	4248740	163	54.9	511	7.4	2.36
CATS114	4.55e+00	360400	4248900	163	65	546	7.6	1.07
CATS120	1.15e+00	360352	4247800	169	65	533	8.5	3.53
CATSVC4	4.85e-01	360296	4248600	169	53.4	533	7	2.17
MAREP02	7.69e-01	359999	4254875	171	7.6	519	12	0.5
MAREP03	9.07e-01	359997	4254878	171	6.7	561	7	0.5
MAREP17	1.04e-03	539991	4254885	174	7.6	533	28.3	0.61
KENELE4	1.39e+01	345500	4248000	185	21	533	2.6	2.1
CALEP11	1.12e+00	361130	4244253	167.6	23	336	13.4	1.22
CALEP12	2.15e-01	361120	4244208	167.6	7	533	3	0.5
CALEP14	3.63e-01	361127	4244198	167.6	36.6	361	21.3	0.9
CALEP21	9.73e-01	361138	4244260	167.6	36.6	361	21.3	1.37
CALEP24	1.41e-01	361036	4244236	167.6	9	505	3	0.4
CALEP26	1.61e-01	361152	4244241	167.6	10	378	16.8	0.57
CALEP31	1.89e+00	361230	4244006	167.6	28	336	15.5	1.52
CALEP32	2.15e-01	361203	4244032	167.6	9	533	3.1	0.46
CALEP34	1.89e+00	361142	4244102	167.6	35	361	21.3	0.97
CALEP39	1.89e+00	361199	4243988	167.6	37	336	15.5	1.27
CALEP40	1.00e+00	361181	4244023	167.6	9	533	3.1	0.46
CALEP42	1.89e+00	361120	4244076	167.6	28	361	21.3	0.97
CALEP45	2.65e+00	360937	4244367	167.6	30	436	18.3	0.84
CALEP64	2.01e-03	361130	4244253	167.6	4.9	505	28.4	0.76
EIDUP01	1.13e+02	344000	4268800	165.8	60	348	10	1.8
KYPOWU1	8.99e+02	359000	4226200	173.1	251.8	434	27	8.6
KYPOWU2	9.83e+02	359000	4226200	173.1	251.8	434	27	8.6
TNGAB1C	7.70e-02	362100	4236800	175.3	8.3	755	54.9	0.52
TNGASB2C	7.70e-02	362100	4236800	175.3	8.3	755	54.9	0.52
TNGASB3C	7.70e-02	362100	4236800	175.3	8.3	755	54.9	0.52
TNGASB4C	7.70e-02	362100	4236800	175.3	8.3	755	54.9	0.52
TNGASB5C	7.70e-02	362100	4236800	175.3	8.3	755	54.9	0.52
TNGASB6C	7.80e-02	362100	4236800	175.3	8.4	755	54.9	0.52
TNGASB7C	7.80e-02	362100	4236800	175.3	8.4	755	54.9	0.52
TNGASB1A	2.10e-02	362100	4236800	175.3	8.5	755	54.9	0.21
TNGASB2A	2.10e-02	362100	4236800	175.3	8.5	755	54.9	0.21
TNGASB3A	2.10e-02	362100	4236800	175.3	8.5	755	54.9	0.21
AKASHB2	3.92e+01	354150	4262420	167	60	1923	59	6
AKASHB1	2.34e+02	354160	4262410	167	61	394	9	3.9
AKASHE5	3.31e+01	354780	4261960	167	27	408	17	5.5
AKASHG3	1.23e+02	354100	4262590	167	24	533	15	2.4
AKASHG4	1.23e+02	354110	4262580	167	24	533	15	2.4
AKASHG5	1.23e+02	354120	4262570	167	24	533	15	2.4
AKASHG6	2.52e+01	354110	4262560	167	28	533	20	2.2

TABLE 3. BOYD COUNTY SO_2 AERMOD MODELING EMISSION INVENTORY								
SOURCE ID	EMISSION RATE (grams/sec)	EMISSION LOCATION X (meters)	Y (meters)	BASE ELEVATION (meters)	STACK HEIGHT (meters)	STACK TEMP (deg. K)	STACK EXIT VEL. (m/sec)	STACK DIAMETER (meters)
AKASHC1	4.65e+01	354180	4262490	167	47	338	25	0.5
AKCOK09	1.94e+00	359430	4257490	167.6	56	533	7	2.9
AKCOK15	2.85e+00	359610	4257350	167.6	67	533	5	3.7
AKCOK19	1.18e+01	359430	4257710	167.6	76	741	7	1.5
AKCOK20	6.19e+01	359500	4257570	167.6	76	527	8	3.4
AKCOK21	6.19e+01	359500	4257570	167.6	76	527	8	3.4
AKCOK22	6.19e+01	359500	4257570	167.6	76	527	8	3.4
AKCOK23	1.11e+01	359490	4257550	167.6	14	490	10	1.4
AKCOK24	5.74e+00	359549	4257805	167.6	25	811	11	0.8
AKCOK26	5.03e-01	359460	4257960	167.6	17	1228	2	3.2
ASHOB001	2.37e+00	355100	4262900	164.7	19.2	533	33	1.1
ASHOB002	4.27e+00	355100	4262900	164.7	19.2	489	43.1	1.2
ASHOB003	2.37e+00	355100	4262900	164.7	19.2	555	33	1.1
ASHOB004	2.99e+00	355100	4262900	164.7	30.5	478	13.9	0.8
ASHOB005	1.42e+00	355200	4262900	164.7	25.9	633	38.2	1.1
ASHOB006	1.32e+00	355200	4262900	164.7	29.3	497	26.5	0.9
ASHOB011	4.40e-01	355200	4262900	164.7	9.9	550	78.9	0.4
ASHOB012	7.49e-01	355200	4262900	164.7	9.6	569	81.3	0.6
ARHAUT0	1.38e+01	342000	4273000	166	15.2	450	15	1.52
ARHAUT0	1.38e+01	342000	4273000	166	15.2	450	15	1.52
ARHAUT0	3.69e+01	342000	4273000	166	15.2	450	15	1.52
ARHAUT0	3.67e+01	342000	4273000	166	15.2	439	8.8	1.98
ARHAUT0	3.67e+01	342000	4273000	166	15.2	439	8.8	1.98
NEWBB008	2.40e+02	332700	4291000	165	38.1	505.4	16	2.74
NEWBB009	2.40e+02	332700	4291000	165	38.1	505.4	16	2.74
NEWBB901	9.10e+01	332700	4290900	165	4	1366.5	4	2.74
IRONCZ	1.69e+00	354520	4263730	165	29	749.8	22.3	1.52
IRON2	8.31e-01	354480	4263800	165	14.5	302.6	15.2	1.32
IRONDMEA	1.97e+00	354430	4263870	165	14.6	293.2	20.7	0.66
IRON4	1.97e+00	354510	4263770	165	14.6	310.9	19.8	1.52
IRON47	1.44e+00	354560	4263680	165	17.4	422	11.5	0.91
IRON51	1.44e+00	354590	4263640	165	14.3	588.7	7.9	0.71
IRON86	1.44e+00	354620	4263600	165	15.9	338.7	16.4	0.81
SWVA001	1.76e+00	375030	4253800	167.8	25	325	26.5	2.4
SWVA008	1.76e+00	375030	4253800	167.8	7.3	325	19.3	2.62
SWVA009	1.42e-01	375030	4253800	167.8	25	325	26.5	2.4
ARIS001	3.55e+01	360700	4246315	182.9	33.9	459	19.6	1.22

Table 4. Source Identification Cross-Reference Table	
Facility name	Modeling ID prefix
Marathon-Ashland Oil-Catlettsburg	CATS
Marathon-Ashland Marine Repair Terminal	MARE
Kentucky Electric Steel	KENELE

Table 4. Source Identification Cross-Reference Table	
Facility name	Modeling ID prefix
Calgon Carbon – Big Sandy	CALEP
EI Dupont	EIDUP
Kentucky Power	KYPOWU
Tennessee Gas Pipeline	TNGAS
AK Steel Ashland	AKASH
AK Steel Coke Plant	AKCOK
Allied Signal/Honeywell	ASHO
Aris/Haverhill	ARHA
New Boston Coke	NEWB
Ironton Iron	IRON
SWVA, Inc.	SWVA
Sunoco	ARIS

Background Ambient Air Quality Data

Background ambient air quality data are required to be added to the model predicted concentrations to demonstrate compliance with the National Ambient Air Quality Standards (NAAQS). These data represent the impacts of emissions from natural sources, nearby sources not explicitly modeled, and unidentified sources. The ambient air quality monitored data from the Holt Street/FIVCO Health Department sulfur dioxide monitor located in Ashland, Kentucky was used to develop the background concentrations. This site represents a regional monitor for the sources in the modeling impact area (see Figure 1 for the location of this monitor). It was chosen primarily because it is not heavily influenced by the major facilities of concern in our modeling analysis (i.e., Calgon Carbon, Sunoco, and Marathon-Ashland). Hourly ambient air quality data from this monitor for 2001 and 2002 were averaged to develop the 3-hour, 24-hour and annual background concentrations. The maximum high-second-high averaged concentration was used as background concentration for the 3-hour and 24-hour SO2 averaging periods. The maximum annual concentration was used for the annual averaging period. Table 5 illustrates the ambient air quality background concentrations used in the modeling demonstration. The background ambient air quality concentrations plus the modeled concentrations must be equal to or less than the EPA NAAQS to demonstrate attainment for the nonattainment area.

Table 5. Monitored Background Concentrations	
Averaging period	**Background concentration (ug/m3)**
3-hour	103.4
24-hour	43.2
Annual	11.0

Modeling Results

The AERMOD modeling analysis indicates that SO2 concentrations are below the 3-hour, 24-hour, and annual NAAQS limits. This indicates compliance with each of the SO2 NAAQS. Table 6 provides a summary of the modeling results. Figure 6 illustrates the locations of the 3-hour highest-second-high (HSH), 24-HSH and annual modeled concentrations. Figures 7, 8, and 9 provide isopleths of the initial coarse grid (1000 m spacing) modeling results. Figure 10 illustrates a plot of the isopleths of HSH modeled concentrations (ug/mg3) within the modeling fine grid indicated for the 3-hour compliance test. Figure 11 illustrates isopleths of maximum HSH modeled concentrations (ug/mg3) within the modeling fine grid for the 24-hour compliance test. Figure 12 illustrates isopleths of maximum-modeled concentrations (ug/mg3) for the annual compliance test. The locations of the highest modeled concentrations (i.e., HSH for 3- and 24-hour averaging periods and maximum annual) are indicated by an "+" in these figures. The modeling analysis indicates that the existing emissions explicitly modeled for facilities included in the modeling inventory along with the current emission rates and operational changes expected to occur at the Sunoco and Calgon facilities are sufficient with the background ambient air quality concentrations to demonstrate compliance with and attainment of the EPA SO2 for the Boyd County, Kentucky SO2 nonattainment area.

Table 6. Summary of SO2 Modeling Results for Boyd County, Kentucky Nonattainment Area					
Averaging Period	**Rank**	**Max Modeled Concentration (ug/m3)**	**Regional Background Concentration (ug/m3)**	**Total Concentration (ug/m3)**	**NAAQS (ug/m3)**
3-hour	HSH	1060.18	103.4	1163.58	1300
24-hour	HSH	306.26	43.2	349.46	365
Annual	H	65.77	11.0	76.77	80

V. Computer Modeling Archive

An archive of all computer-modeling files is attached and available on the attached CD. The following is a description of the files included:

Directory:\BPIP-PRIME – contains all input and output files for the BPIP-PRIME program.

Directory:\ AERMET – contains all input and output files for the AERMET preprocessor.

Directory:\AERMAP -- contains all input and output files for the AERMAP preprocessor.

Directory:\ AERMOD – contains all input and output files for the AERMOD model.

Directory:\Surface Characteristics – contains spreadsheet used to determine the surface parameters: albedo, surface roughness, Bowen ratio.

Figure 1.
Meteorological Stations and Background SO2 Monitor Locations

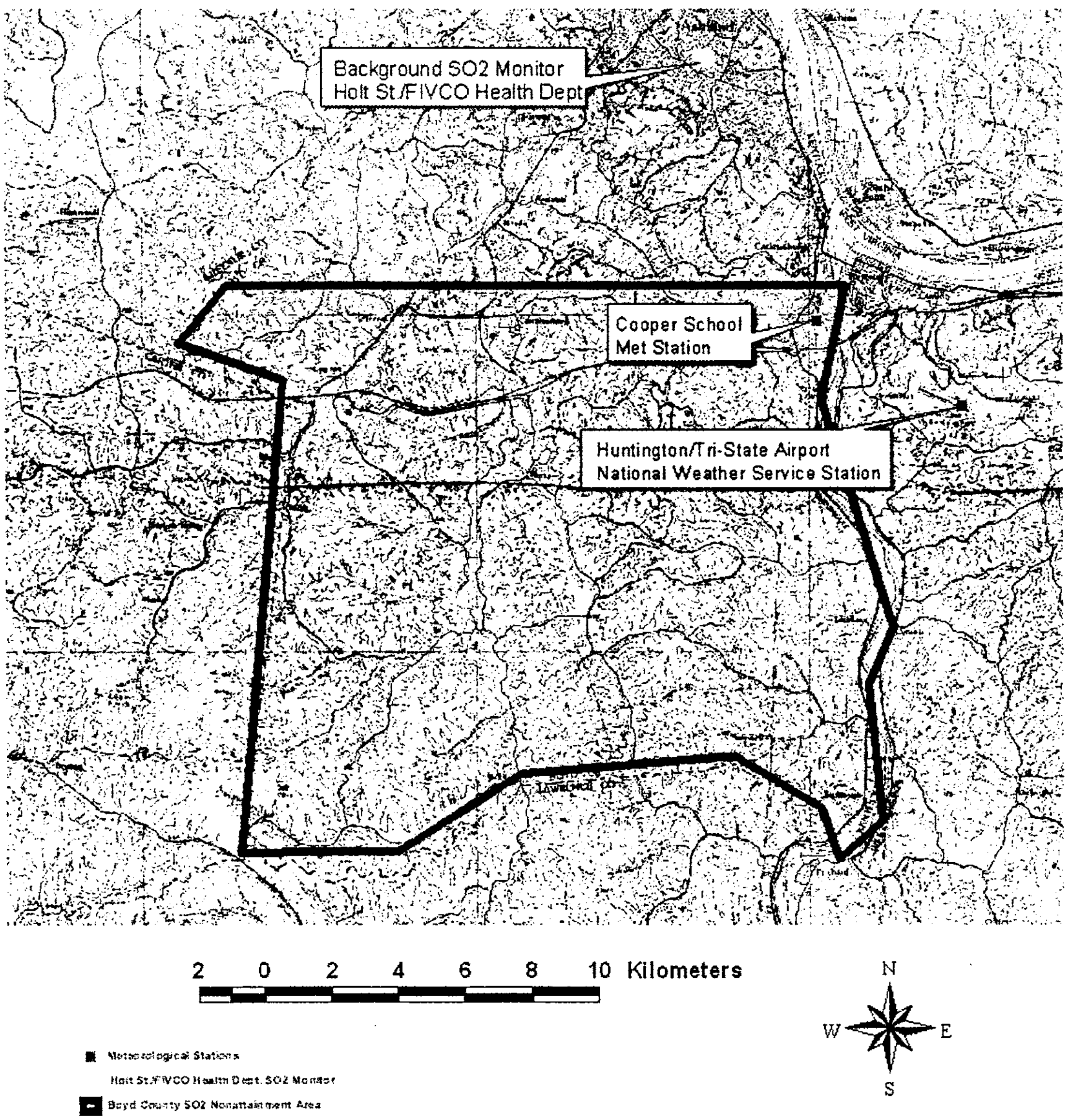

Figure 1.1
1991 Annual Wind Rose
Cooper School Meteorological Data

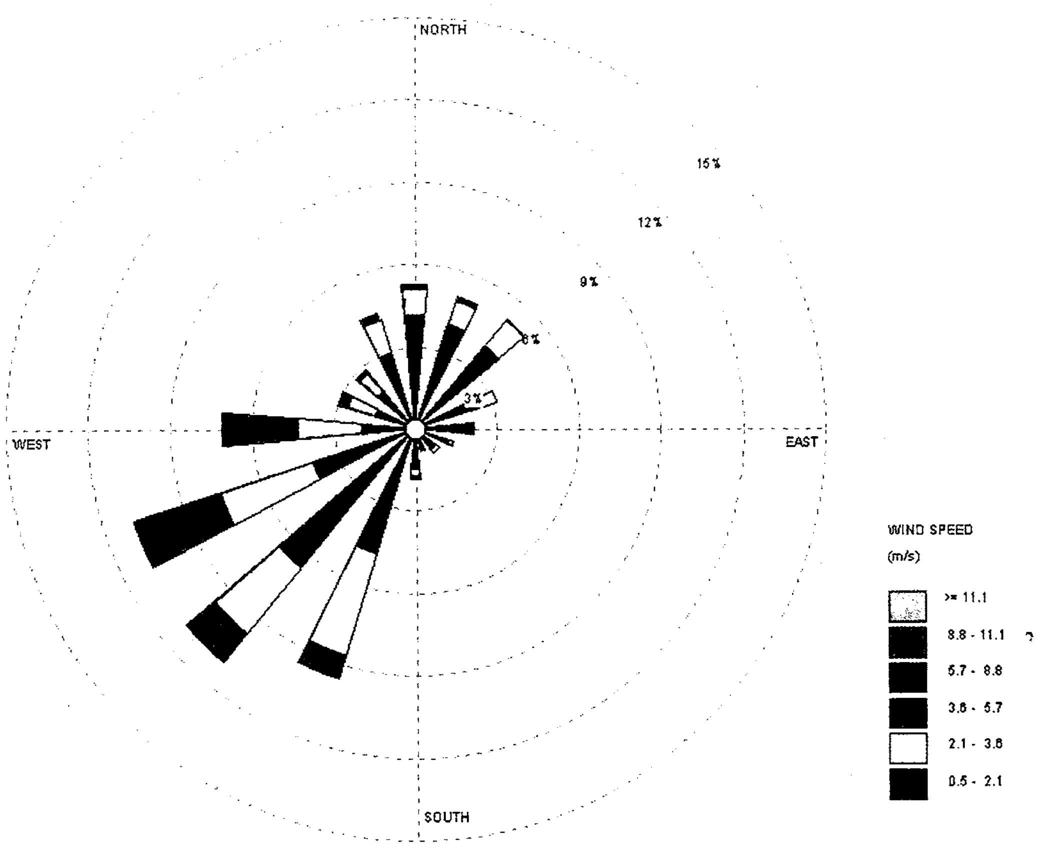

Figure 2.
Cooper School Land Use

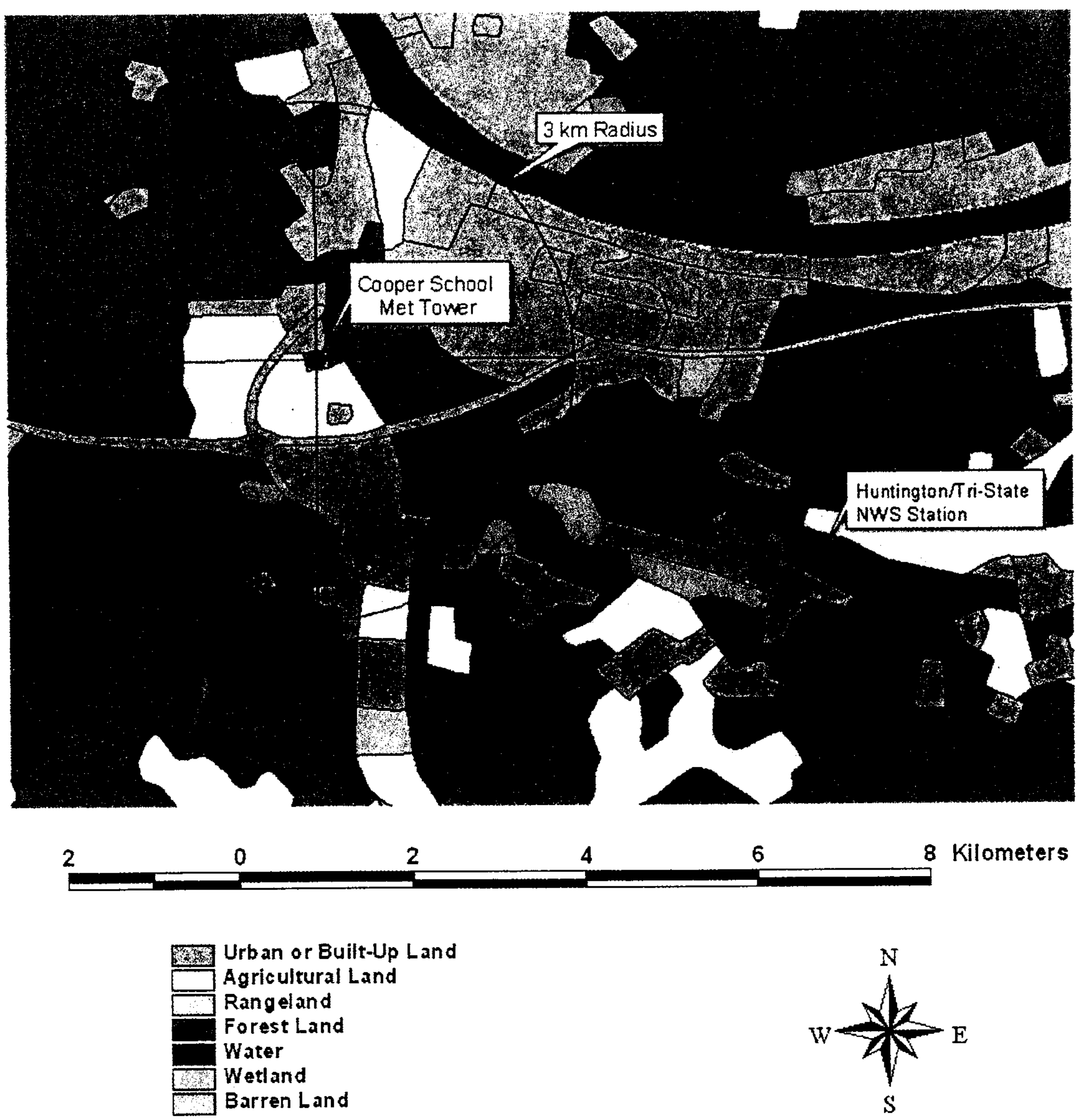

Figure 3.
SO2 Emission Sources and Boyd County Non-attainment Area

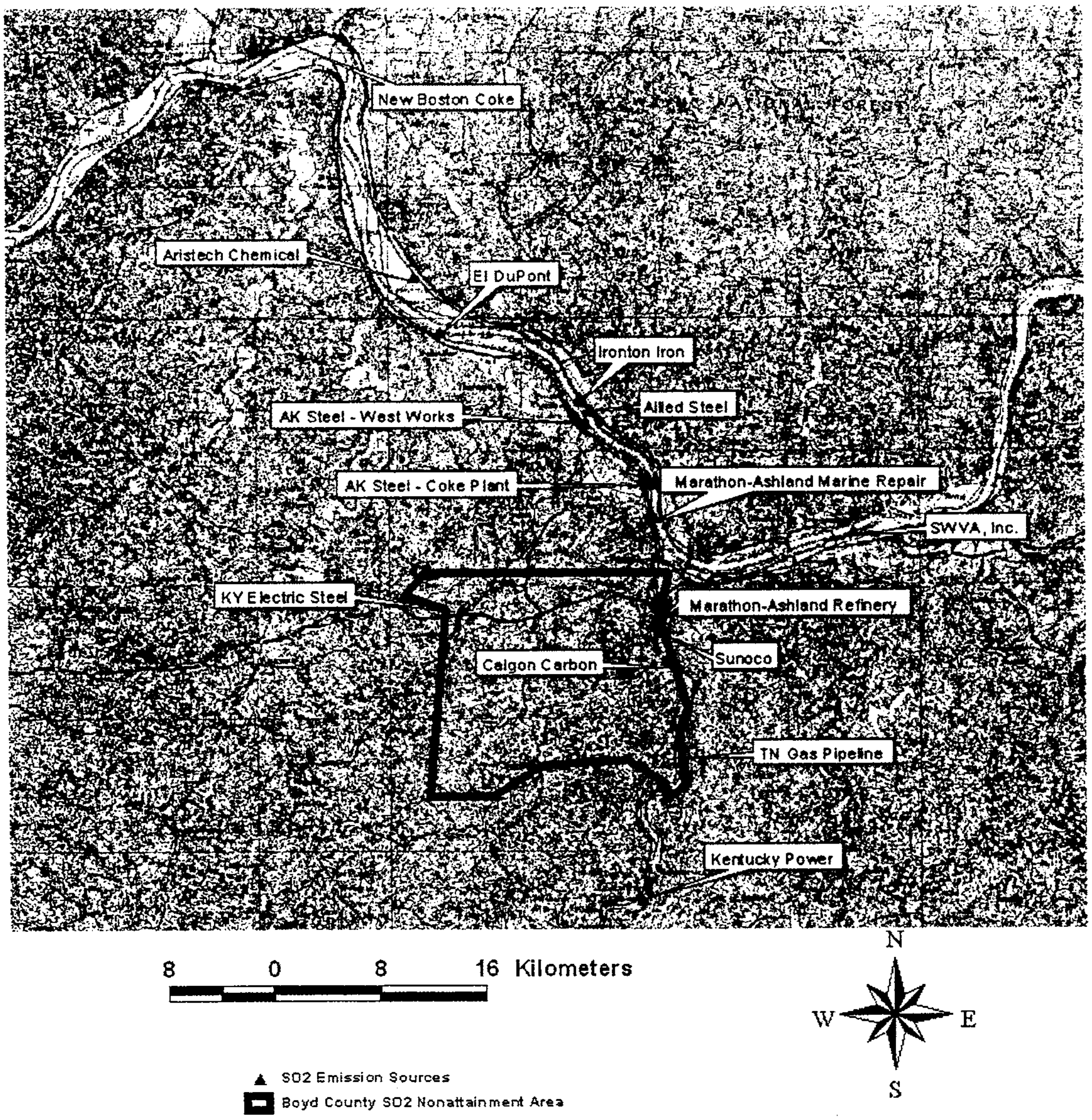

Figure 3.1
Topographic Contours Covering the Final Modeling Receptor Grid

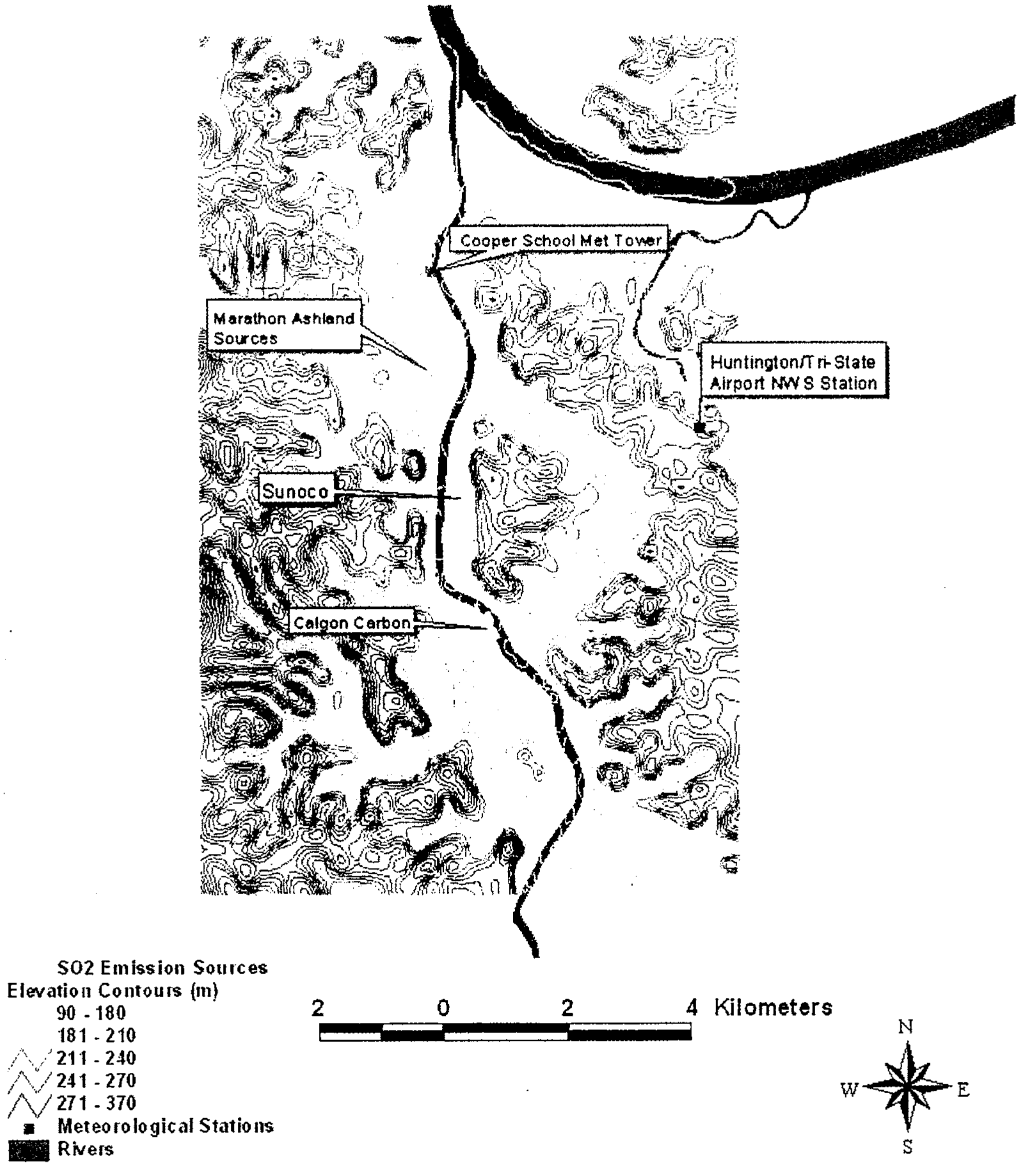

Figure 4.
Receptor Grids

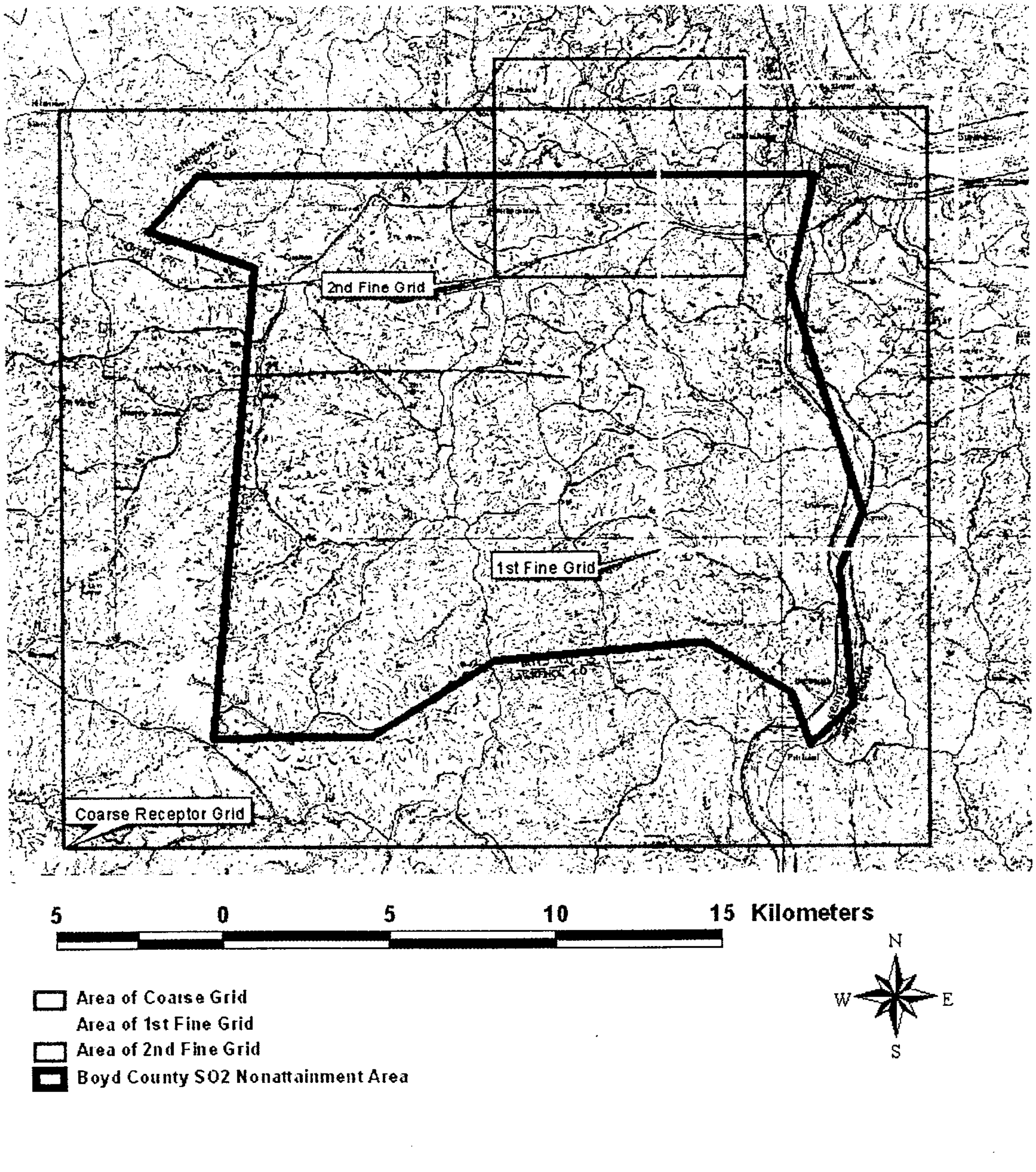

Figure 5.
Sources Modeled for Building Downwash

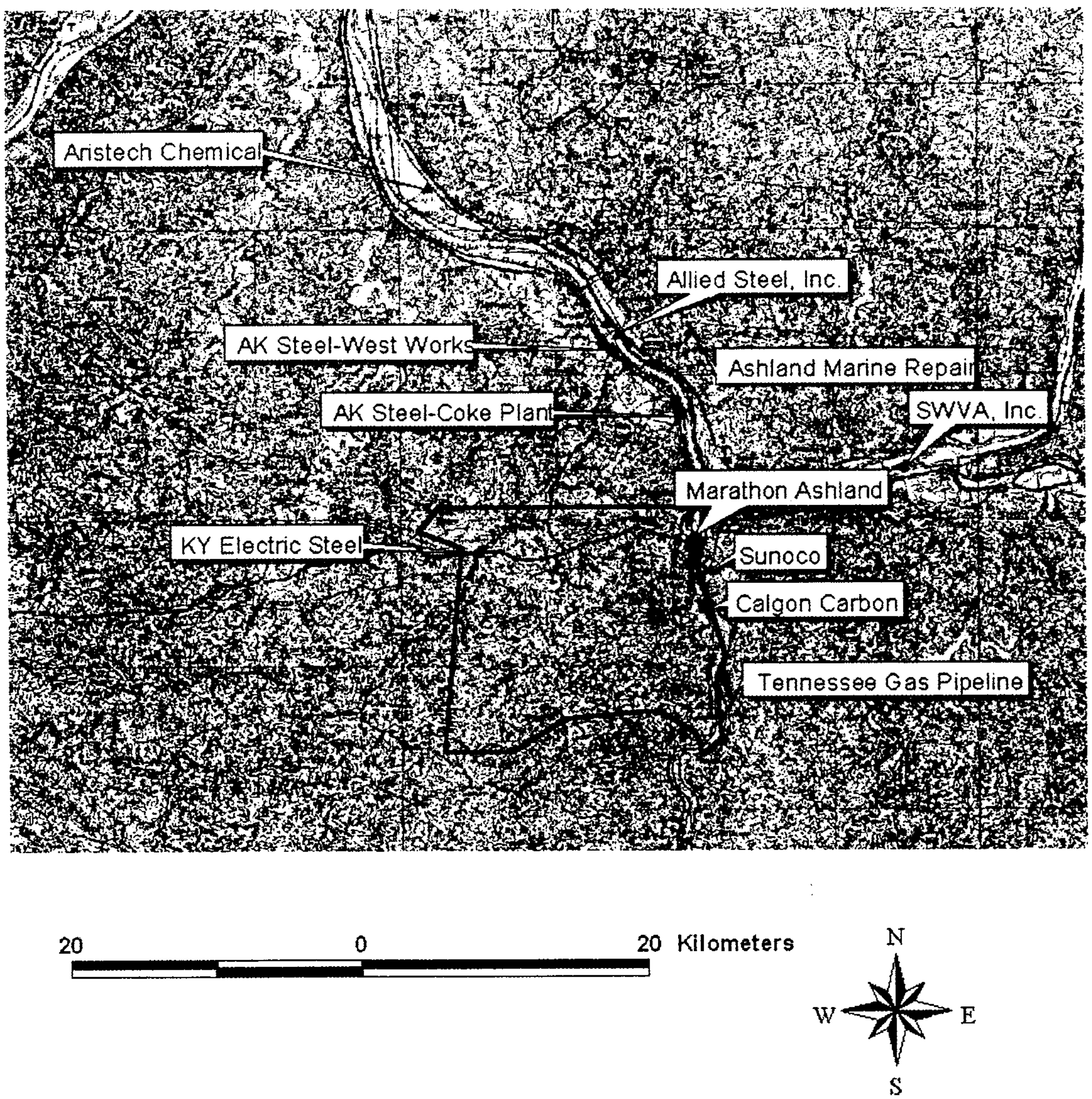

Figure 6.
Locations of Modeled 3hr and 24hr High-Second-High and Maximum Annual Concentrations

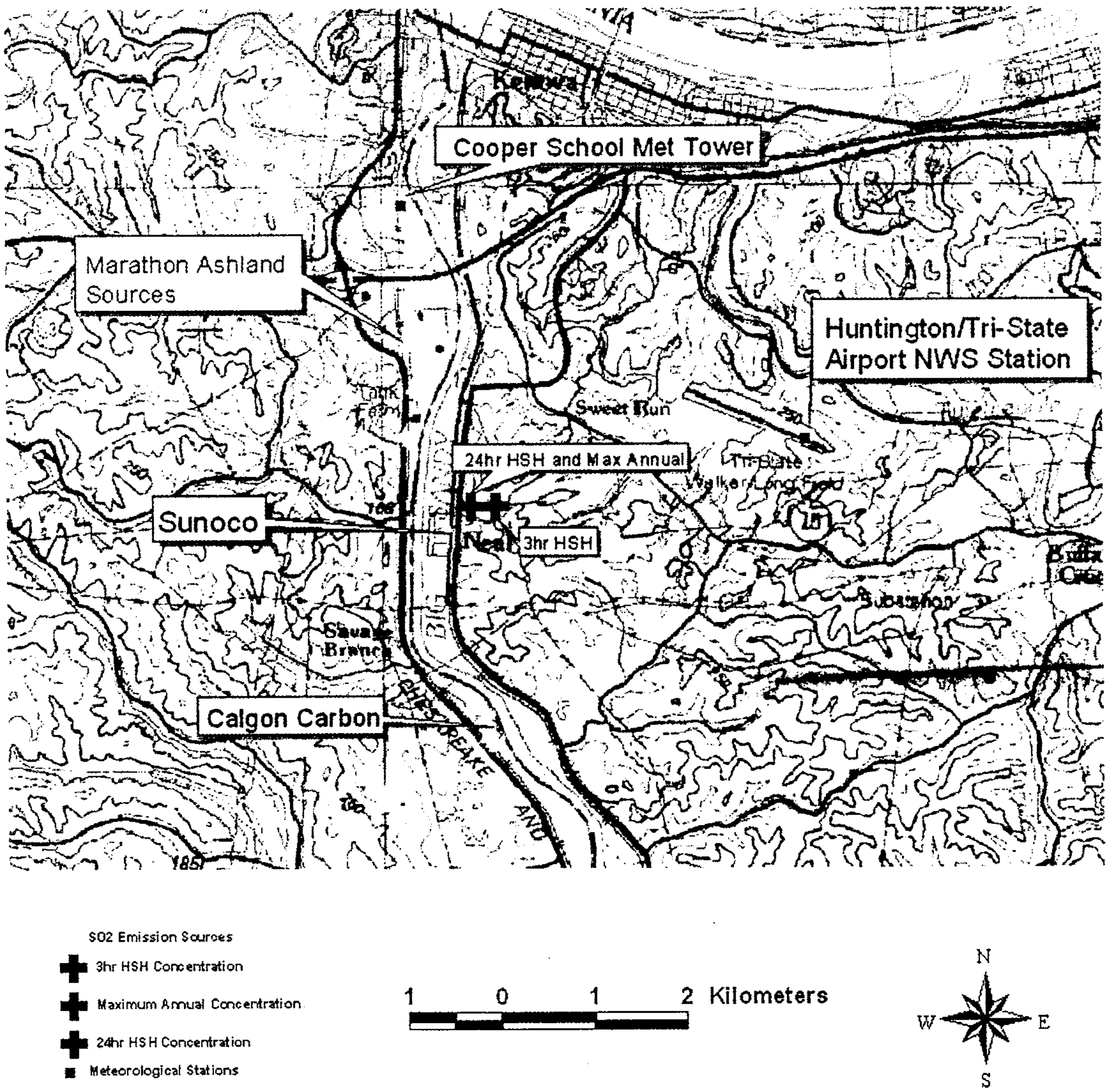

Figure 7.
Coarse Grid 3hr HSH
Concentration Isopleths

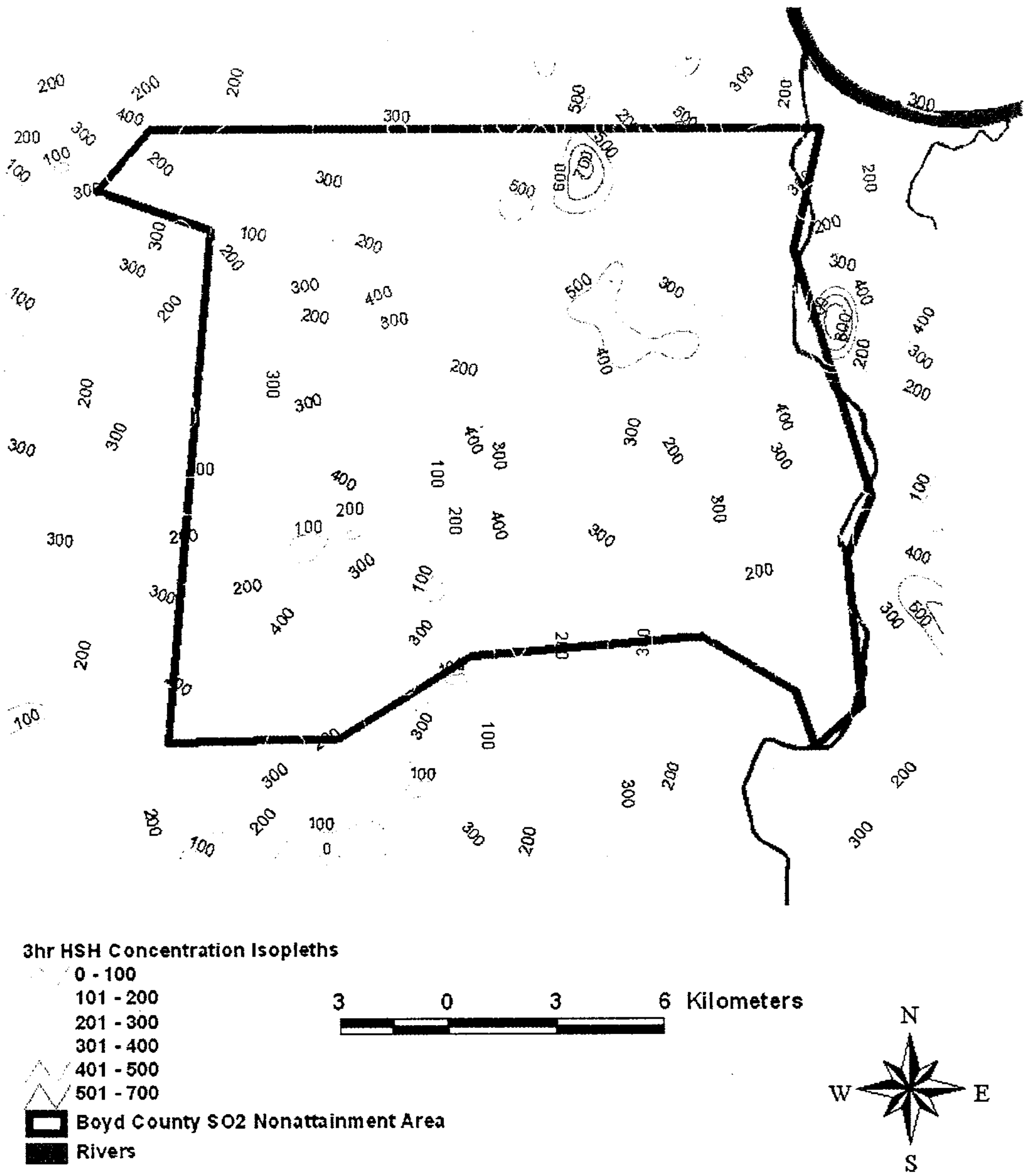

Figure 8.
Coarse Grid 24hr HSH Concentration Isopleths

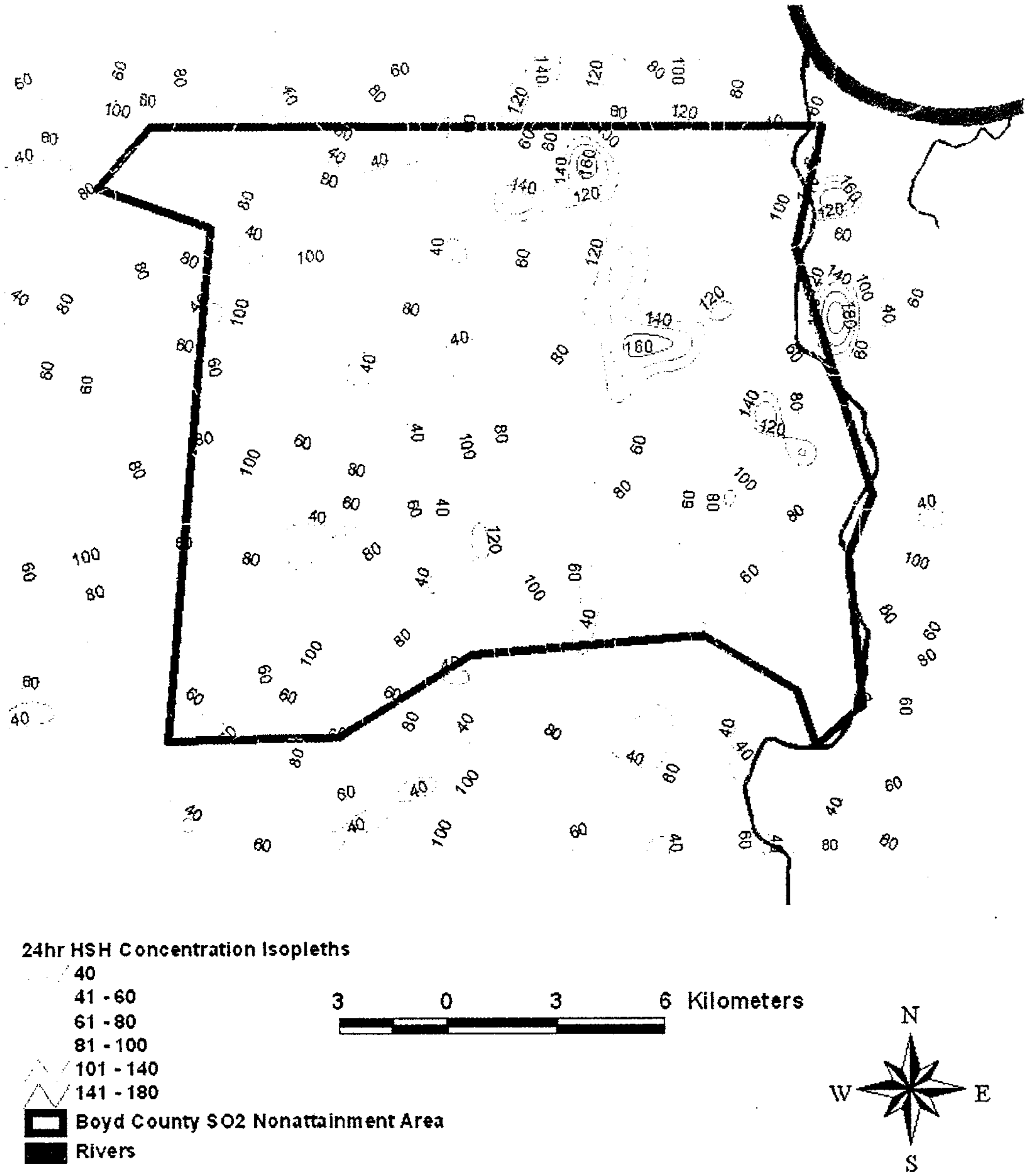

Figure 9.
Coarse Grid Maximum Annual Concentration Isopleths

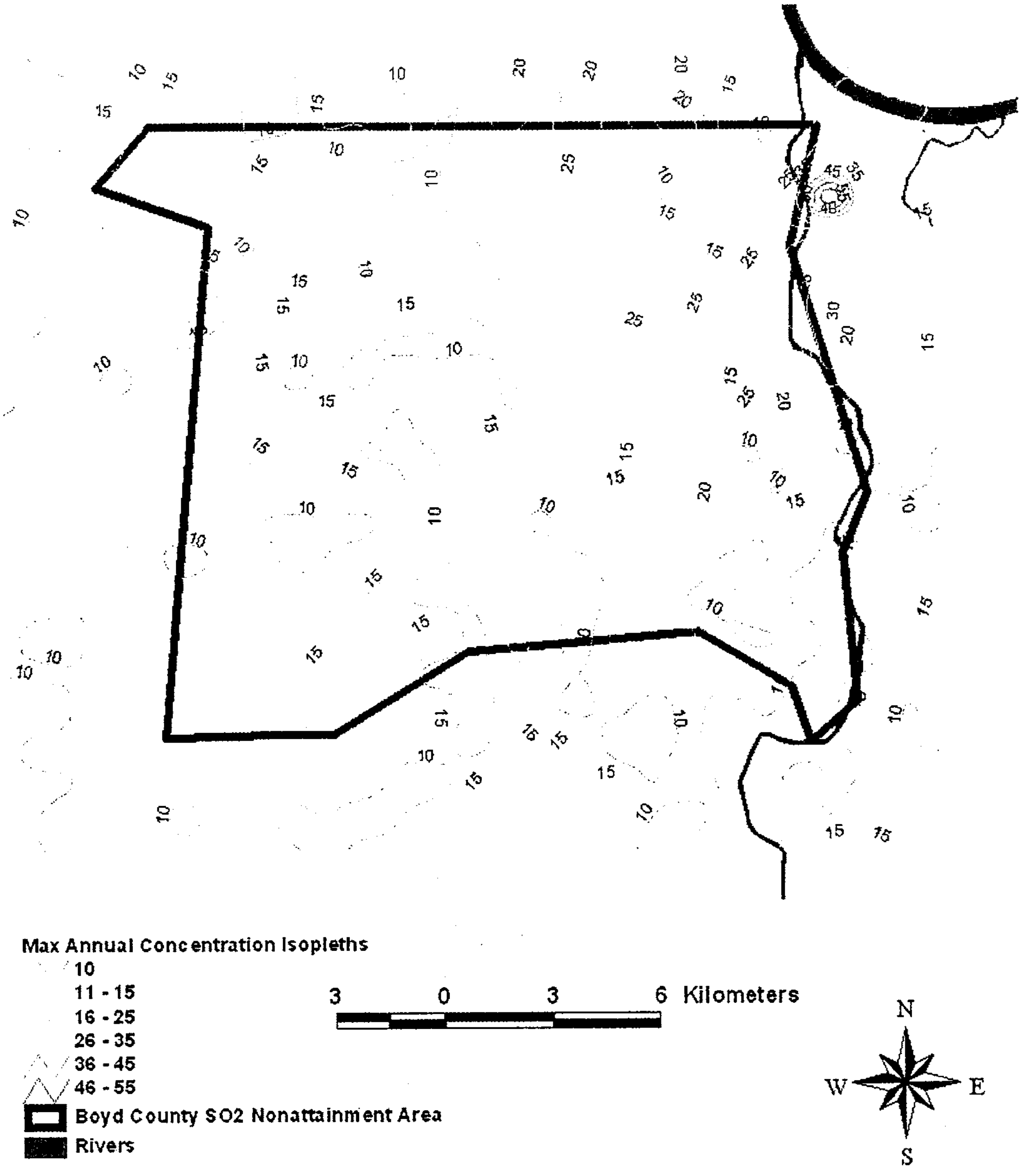

Figure 10.
3hr HSH Concentration Isopleths

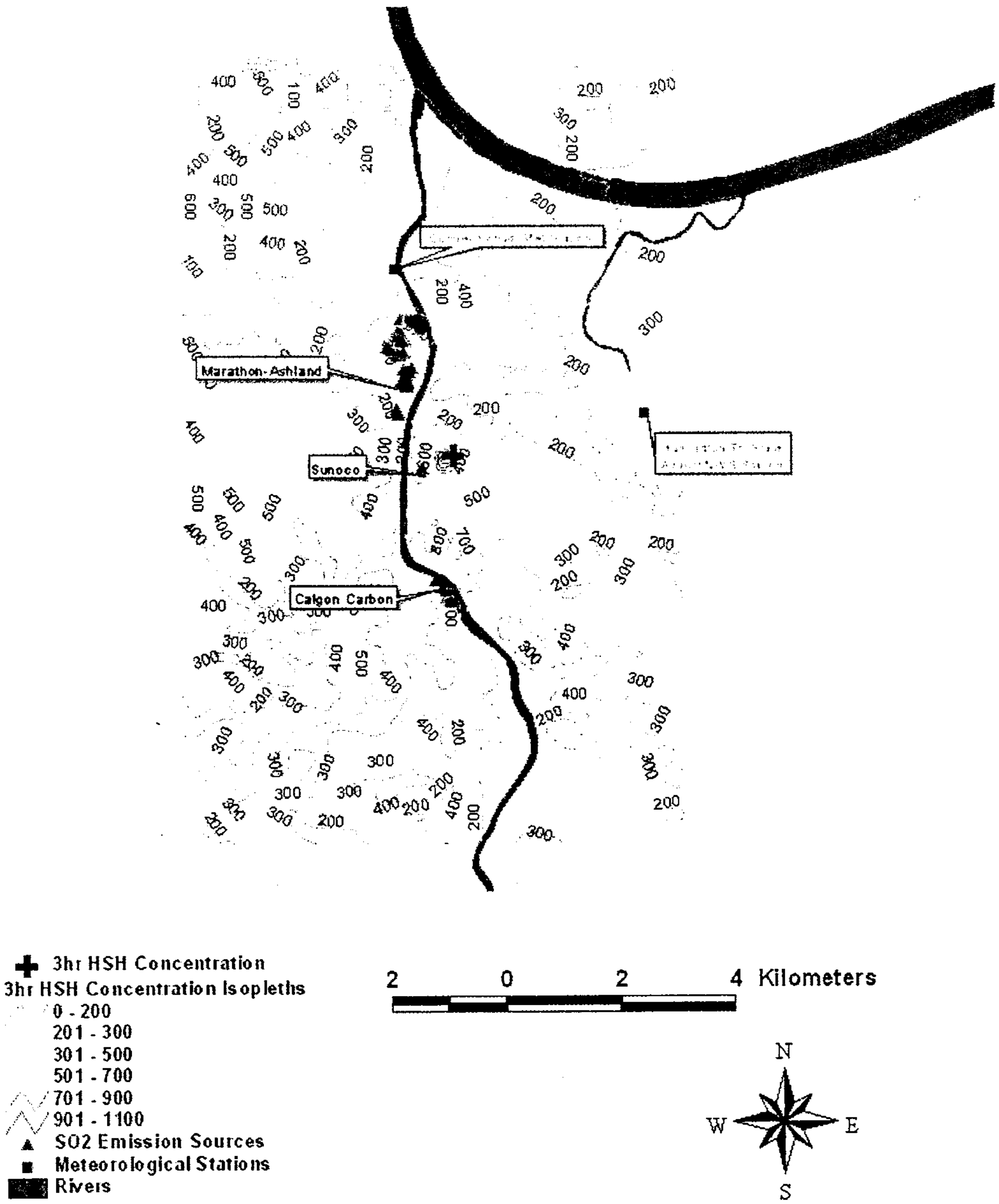

Figure 11.
24hr HSH Concentration Isopleths

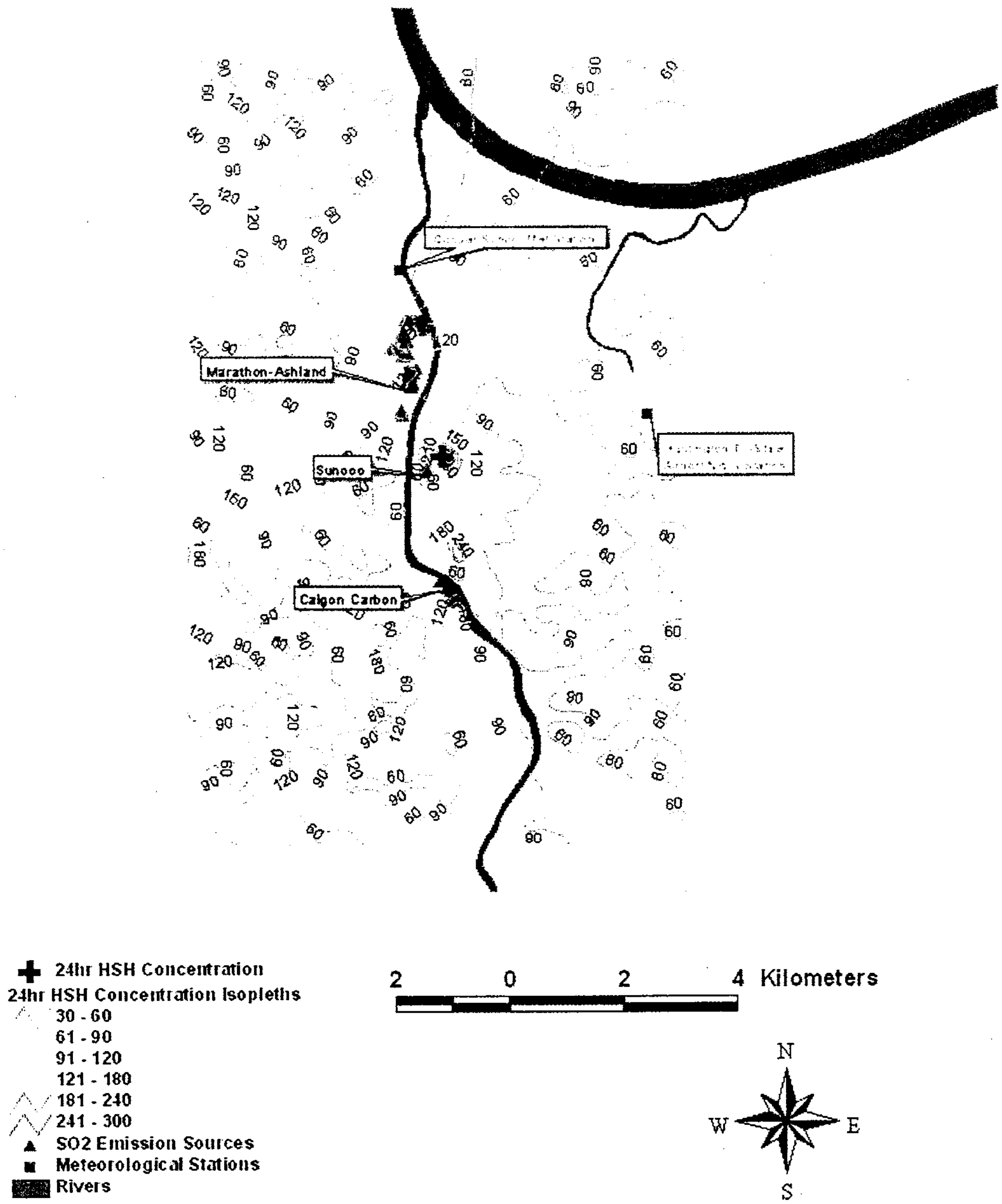

Figure 12.
Maximum Annual Concentration Isopleths